

rejections were: (1) the deletion of the phrase "without excitation of the substrate surface," which had been added to claim 1 in the amendment dated June 13, 2003, and (2) the addition of the phrase "via the opening" to claim 1.

Under MPEP §706.07(a), third paragraph a second or subsequent action on the merits of any application may not be made final if it includes a rejection, on prior art not of record in the preceding rejection, of any claim amended to include limitations that should reasonably have been expected to be claimed. In short, the only difference between claim 1 in the Amendment of September 25, 2003, and original claim 1 is the phrase "via the opening." Since an opening was recited in original claim 1, the September 25, 2003, Amendment of claim 1 did not add any limitations that could not be anticipated. Therefore, the present finality of the rejections is improper.

Regarding the statement in the Office Action that one cannot show nonobviousness by attacking the references individually where the rejections are based on combinations of references (Final rejection page 5, penultimate paragraph), Applicant submits the following two points. First, the previous Office Action, dated June 25, 2003, did not contain any art-based rejections; instead, the pending claims were rejected only under 35 USC §112, first paragraph. Second, Applicant's remarks

presented in the Response dated September 25, 2003 were provided only to convey a better understanding of the differences between the present invention and those described in references previously identified by the Patent and Trademark Office, not to overcome a rejection. Moreover, these remarks did not attack the references individually, but instead showed a deficiency in the findings of fact in the Final Rejection, i.e., that the individual references did not teach the features for which they were cited in the Final Rejection, dated February 13, 2003. If a reference fails to teach a feature or motivation for which it is cited in a rejection, the *prima facie* case of unpatentability is overcome to the extent the rejection relies on this reference for the proposed teaching.

Regarding the alleged equivalence of beam epitaxy and chemical vapor epitaxy (Final Rejection page 6, third paragraph), Applicant submits that the chemical vapor deposition (CVD) technique uses a raw material gas, which is introduced into a chamber where a substrate is prepared and set. That is, with the CVD technique, the substrate is disposed under an atmosphere containing the raw material gas. In this case, since the substrate is contacted with the raw material gas, the constituent elements of the raw material gas are deposited onto the substrate

through thermal decomposition or the like. Therefore, the raw material gas does not have directional characteristic.

By contrast to CVD, the molecular beam epitaxy (MBE) technique uses a molecular beam or an atomic beam, which is directed at a substrate in a chamber. In this case, the beam is directly supplied onto the substrate, so that the beam has a directional characteristic.

In this way, the CVD technique is quite different in principle from the MBE technique because the raw material (raw material gas) of the CVD technique does not have a directional characteristic and the raw material (beam) of the MBE technique does have a directional characteristic.

In Tokunaga, the CVD technique and the MBE technique are described as film-forming techniques without regard for the difference in principle between them. The MBE technique can not simply be substituted for the CVD technique.

Conventionally, the epitaxial lateral overgrowth (ELO) technique only relates to the CVD technique, not to the MBE technique. In reality, Tanaka only refers to the CVD technique in connection with the ELO technique. Therefore, since the CVD technique is quite different in principle from the MBE technique, the ELO technique can not be applied to the MBE technique without some suggestion. Strictly speaking, since the ELO technique uses

non-directional raw material, such as raw material gas, the ELO technique is different from the present invention because the present invention relates to the MBE technique and, thus, uses directional raw material, such as a molecular or atomic beam.

Regarding the allegation in the Final Rejection that Nakamura teaches MBE at beam angles of zero to 90 degrees, Applicant submits that Nakamura teaches a normal incident angle for the substrate in the MBE technique. If, in the MBE technique, the incident angle is beyond 0-90 degrees, the molecular or atomic beam can not be introduced onto the substrate. As previously mentioned, in the conventional MBE technique, the incident angle is set around 90 degrees so the molecules or atoms of the beam are deposited at a higher rate. If the incident angle is set to lower angle range, as defined in the present invention, the molecules or atoms can not be deposited onto the substrate at a high rate, so that regardless of Nakamura, in the conventional MBE technique, the lower incident angle range can not be employed.

Claims 1-6, 11-18, and 20-23 stand rejected, under 35 USC §103(a), as being unpatentable over Tanaka et al. (US 6,377,596) in view of Tokunaga et al. (US 5,425,808) and Nakamura et al. (JP 01-234389A). Applicant respectfully traverses.

Claim 1 recites:

*A method for forming a single crystalline film comprising the steps of:*

*forming an amorphous film on a single crystalline substrate,*

*forming an opening in the amorphous film and thereby exposing a part of a surface of the substrate, and*

*introducing atomic beams, molecular beams or chemical beams onto the surface of the substrate at their incident angle of not more than 40 degrees with respect to the substrate surface under a reduced atmosphere and thereby selectively and epitaxially growing a single crystalline film on the exposed surface of the substrate via the opening.*

The Final Rejection proposes that Nakamura discloses a molecular ray method of performing epitaxy wherein the angle of incidence between the substrate and the molecular beam can be optimized between zero and 90 degrees (Final Rejection page 3, fourth paragraph). Continuing, the Office Action proposes that it would have been obvious to combine the teachings of Nakamura with those of Tanaka and Tokunaga because optimizing the angle of incidence between the beam and the substrate surface would positively affect the product (Final Rejection page 3, fifth paragraph).

However, it is submitted that these findings in the Final Rejection are unwarranted. Nakamura discloses in Figs. 1 and 2 that epitaxial growth is optimized when a molecular beam from a source 2, 3 strikes a substrate 6 at an angle perpendicular to its surface. Additionally, these figures illustrate that the

rate of epitaxial growth decreases as the angle at which the molecular beam strikes the substrate surface decreases from 90 degrees to zero degrees.

By contrast to the teachings of Nakamura, Applicant's claimed method achieves an increasing amount of epitaxial lateral overgrowth as the angle at which the molecular beam strikes the substrate surface decreases from 90 degrees toward zero degrees. In an exemplary but non-limiting embodiment of Applicant's invention, illustrated by Figs. 1-3, the molecular beam particles 6-1 and 6-3 that impinge on amorphous film 2 are entirely reflected, or nearly so, with few if any of the particles being deposited on amorphous film 2 (specification page 3, lines 16-19). The molecular beam particles 6-2 impinging on an exposed surface 1A of single crystalline substrate 1, through opening 3, are almost entirely deposited with few if any being reflected (specification page 3, lines 19-21).

Referring now to application Fig. 2, as particles 6-2 continue to be deposited in opening 3, the deposited single crystalline film 7 grows up and out of opening 3 such that its upper surface 7a is higher than the upper surface of the surrounding amorphous film 2 (specification page 3, lines 23-25). Also, side surface 7B of the deposited film 7 becomes exposed to the molecular beam.

With side surface 7B exposed, molecular beam particles 6-5 impinging on side surface 7B begin to deposit on single crystalline film 7 without being reflected (specification page 3, line 27, through page 4, line 3). As illustrated in Fig. 3, a lateral single crystalline film 9 grows laterally overtop of amorphous film 2 as the epitaxial growth continues on side surface 7B (specification page 4, lines 6-8).

As stated in the Final Rejection, Nakamura discloses optimizing the angle of incidence between the substrate and the molecular beam to positively affect the product (Final Rejection, page 3, fifth paragraph). As illustrated in Figs. 1 and 2, Nakamura discloses that the product is increasingly positively affected by reducing the angle between the molecular beam and an angle perpendicular to the substrate surface. Additionally, Nakamura discloses that the optimal positive effect on the product is achieved by directing the molecular beam perpendicular to the substrate's surface.

The epitaxial lateral overgrowth provided by Applicant's method of claim 1 is substantially incapable of being achieved by a molecular beam directed perpendicularly to the substrate surface. This is because the molecular beam particles would be directed along an axis that is parallel to side surface 7B.

Thus, the particles would never strike side surface 7B to produce the lateral epitaxial overgrowth of amorphous layer 2.

Combining the teachings of Nakamura with those of Tanaka and Tokunaga in the manner proposed in the Final Rejection for obtaining the optimal crystal would render the proposed method unsatisfactory for, if not entirely incapable of achieving, its intended purpose. If the proposed modification would render the prior art invention being modified unsuitable for its intended purpose, then there is no suggestion or motivation to make the proposed modification. See MPEP §2143.01 fifth subheading, first paragraph; see also *In re Gordon*, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984).

In short, Nakamura teaches away from the claimed feature of introducing atomic, molecular, or chemical beams onto the surface of a substrate at an incident angle of not more than 40 degrees with respect to the substrate surface. Instead of the claimed feature, Nakamura teaches that 90 degrees is the optimal angle for epitaxial growth. Proceeding contrary to accepted wisdom in the art is evidence of nonobviousness. See MPEP §2145(X) (D) (3); see also *In re Hedges*, 783 F.2d 1038, 228 USPQ 685 (Fed. Cir. 1986).

When previously presented with these arguments, the Patent and Trademark Office (Office) replied that these arguments do not

hold because Nakamura discloses in Fig. 2 that the grown crystal is multi-component and deposition from multiple sources is suggested (Advisory Action dated May 21, 2003). Applicant submits that the proposed multi-component aspect of the grown crystal is irrelevant to a determination of whether Nakamura teaches away from the claimed combination. Regarding the statement in the Advisory Action that Nakamura discloses multiple deposition sources and therefore teaches the optimization features recited in claim 1, Applicant respectfully disagrees with this conclusion. Nakamura discloses that both of the disclosed molecular deposition sources provide similar performance.

Curve A of Nakamura's Fig. 2(b) corresponds to a molecular ray source 2 that is disposed to provide a molecular beam directed perpendicularly to a longitudinal axis of substrate 1, when angle  $\Theta$  has a value of zero. Curve B of Nakamura's Fig. 2(b) corresponds to molecular ray source 3 that is disposed to provide a molecular beam directed parallel to the longitudinal axis of substrate 1, when angle  $\Theta$  has a value of zero.

When the beam of molecular ray source 2 strikes substrate 1 perpendicularly to its longitudinal axis, the epitaxial growth rate provided by this source reaches its peak value. This condition is indicated in Fig. 2(b) by the value for curve A at

$\Theta=0^\circ$ . Similarly, molecular ray source 3 achieves its peak epitaxial growth rate when its beam strikes substrate 1 perpendicularly to its longitudinal axis. This condition is indicated in Fig. 2(b) by the value for curve B at  $\Theta=90^\circ$ .

When the beam of molecular ray source 2 strikes substrate 1 parallel to the longitudinal axis of substrate 1, the epitaxial growth rate provided by this source reaches its lowest value. This condition is indicated in Fig. 2(b) by the value for curve A at  $\Theta=90^\circ$ . Similarly, molecular ray source 3 achieves its lowest epitaxial growth rate when its beam strikes substrate 1 parallel to the longitudinal axis of substrate 1. This condition is indicated in Fig. 2(b) by the value for curve B at  $\Theta=0^\circ$ .

Both curves A and B illustrate a maximum epitaxial growth rate when the respective molecular ray source directs its beam perpendicularly to the longitudinal axis of substrate 1. As the angle of incidence for the beam of either source moves from a perpendicular angle to a parallel angle of incidence, the growth rate continuously decreases from a maximum rate to a minimum rate. Therefore, the multiple molecular ray sources provide similar epitaxial growth rates relative to their respective angles of incidence with substrate 1. Moreover, this conclusion follows regardless of the number of molecular ray sources used or their respective positioning relative to one another. Therefore,

the conclusion stated in the Advisory Action - that Applicant's optimization argument does not hold because Nakamura discloses multiple source deposition - is not supported by the evidence.

To the extent the Advisory Action may have been suggesting that Nakamura discloses simultaneous multiple source deposition, Nakamura's Figs. 1 and 2 and the English language abstract provide no support for such an inference.

In accordance with the above discussion, Applicant submits that the combined teachings of Tanaka, Tokunaga, and Nakamura fail to provide a disclosure, suggestion or motivation to introduce atomic, molecular, or chemical beams onto the surface of a substrate at an incident angle of not more than 40 degrees with respect to the substrate surface, as recited in claim 1. Therefore, allowance of claim 1 and all claims dependent therefrom is warranted.

The Final Rejection also proposes that the combination of applied references suggest optimizing the incident angle between the substrate surface and the beam during the epitaxial lateral overgrowth (Final Rejection page paragraph bridging pages 3 and 4).

However, the only suggestion the Final Rejection identifies is that provided by Nakamura. The Final Rejection does not identify a similar suggestion provided in Tanaka or Tokunaga or

by their combined teachings. For the reasons discussed above, Nakamura cannot provide the suggestion to achieve the claimed incident angle because Nakamura teaches away from such a suggestion. Since the other two references suggest no such motivation and the Final Rejection does not specifically identify such a suggestion in them, the proposal that the combined teachings of Nakamura, Tanaka, and Tokunaga suggest the claimed incident angle is not supported by the evidence.

Regarding the proposal in the Final rejection that the claimed incident angle would have the anticipated result of optimizing the epitaxial lateral overgrowth (Final Rejection page 4, lines 2-3), Nakamura illustrates in Figs. 1 and 2 that an incident angle that is 50 degrees or more from perpendicular does greatly reduces the epitaxial growth rate for Nakamura's invention. Since Nakamura so clearly teaches away from the claimed limitation, the evidence cannot support the Office's proposed conclusion that the claimed incident angle would have the anticipated result of optimizing the epitaxial lateral overgrowth.

Moreover, the claimed invention provides unexpectedly superior results over the related art. As illustrated in the exemplary but non-limiting embodiment of Fig. 3, the dislocations generated in the single crystalline films 4 and 7, from the

lattice mismatch between substrate 1 and films 4 and 7, propagate in a direction almost perpendicular to the surface of substrate 1, and not in a direction parallel to the surface (specification page 4, lines 9-13). Thus, the single crystalline film 8 may have dislocations, but the single crystalline film 9 formed laterally on amorphous film 2 has very few dislocations (specification page 4, lines 13-16).

In several exemplary but non-limiting examples of Applicant's process, the single crystalline film 9 formed laterally on amorphous film was characterized by a transmission electron microscope as having a dislocation density of not more than  $10^2 \text{ cm}^{-2}$  (specification page 11, lines 23-25, page 12, lines 7-9, lines 18-19, lines 27-28, page 13, lines 21-23, page 14, lines 6-8, page 15, lines 2-4, and page 15, line 27, through page 16, line 1). By contrast to Applicant's superior results, Tanaka discloses a dislocation density in the range of  $10^4$  to  $10^5 \text{ cm}^{-2}$  (Tanaka col. 4, lines 27-29).

"Evidence that a compound is unexpectedly superior in one of a spectrum of common properties ... can be enough to rebut a *prima facie* case of obviousness." *In re Chupp*, 816 F.2d 643, 646, 2 USPQ2d 1437, 1439 (Fed. Cir. 1987); MPEP §716.02(a) second subheading, first paragraph.

In accordance with the above discussion, Applicant submits that Tanaka, Tokunaga, and Nakamura fail to teach or suggest the benefits accruing from the instant claimed method. Accordingly, the combined references do not provide a suggestion or motivation to perform the claimed method. Therefore, allowance of claim 1 and all claims dependent therefrom is warranted for this independent reason.

Dependent claim 17 recites introducing atomic, molecular, or chemical beams onto the surface of a single crystalline substrate to grow a single crystalline film on the exposed surface of the substrate. Additionally, claim 17 recites that the single crystalline substrate and single crystalline film are of different materials.

The Final Rejection states that Tanaka discloses growing GaN on a single crystalline sapphire substrate using an epitaxial lateral overgrowth (ELO) technique (Final Rejection page 4, penultimate paragraph). The Final Rejection acknowledges that Tanaka does not disclose molecular beam epitaxy (MBE) as the method of GaN semiconductor growth (Final Rejection page 2, penultimate paragraph). Continuing, the Final Rejection states that Tokunaga discloses laterally overgrowing GaAs on an amorphous film (Final Rejection page 2, last paragraph). Additionally, the Final Rejection states that Tokunaga suggests

the equivalence of MBE and chemical vapor deposition (CVD) for the growth of epitaxial films (Final Rejection page 2, last paragraph). Based on this information, the Final Rejection proposes that it would have been obvious to combine the references because Tokunaga suggests an equivalent method of growing selective epitaxial nitride films upon amorphous masking layers (Final Rejection page 3, second paragraph).

While Tokunaga may suggest the interchangeability of MBE and CVD in the process of forming "a thin film by photolithography of the prior art," Tokunaga does not suggest their interchangeability for epitaxially growing a single crystalline film of one material on a single crystalline substrate of a different material (see Tokunaga col. 1, lines 24-33, for the above quoted text). To the contrary, Tokunaga discloses that "selective deposition methods are known in which a monocrystal substrate is covered partially with an amorphous thin film, and the same material as the substrate is epitaxially grown only at the exposed portion of the monocrystal substrate" (Tokunaga col. 2, lines 13-17). "[T]hese selective deposition methods rely on growing selectively the monocrystal semiconductor of the same kind from the exposed surface of the monocrystal substrate" (emphasis added) (col. 2, lines 28-31). Therefore, Tokunaga teaches away from the claimed combination recited in claim 17.

It is improper to combine references where the references teach away from their combination. See MPEP §2145(X)(D)(2); see also *In re Grasselli*, 713 F.2d 731, 743 218 USPQ 769, 779 (Fed. Cir. 1983).

Since Tokunaga teaches that a single crystalline film can only be epitaxially grown on a single crystalline substrate of the same material, the evidence cannot support a conclusion that Tokunaga teaches epitaxially growing a single crystalline film of one material on a single crystalline substrate of a different material. Extending this principle, it follows that the evidence cannot support the Office's proposal that Tokunaga suggests the interchangeability of MBE and CVD for epitaxially growing a single crystalline film of one material on a single crystalline substrate of a different material.

In summary, Tokunaga fails to provide the teaching for which it is cited in the Final Rejection and the Final Rejection does not propose that Tanaka or Nakamura provide this same teaching. Accordingly, the combined references do not provide the suggestion or motivation to achieve the claimed method recited in claim 17. Therefore, allowance of claim 17 is warranted.

Claim 18 more definitely recites the features of: (1) forming the single crystalline film on the surface of the single crystalline substrate; and (2) forming the single crystalline

substrate and the single crystalline film using different materials. This claim states that the single crystalline film and a surface layer of the single crystalline substrate, upon which the single crystalline film is formed, have different molecular structures.

In accordance with the above discussion, Applicant submits that the combined teachings of Tanaka, Tokunaga, and Nakamura fail to provide the suggestion or motivation to introduce atomic, molecular, or chemical beams onto the surface of a substrate to form a single crystalline film of a first material, or molecular structure, on the surface of a single crystalline substrate of a different material or molecular structure, as claimed by Applicant. Therefore, allowance of claims 17 and 18 and all claims dependent therefrom is warranted.

With regard to claims 20-23, the Final Rejection states that it would have been obvious to one of ordinary skill in the art to use GaAs as the single crystalline film and sapphire as the single crystal substrate because sapphire or GaAs substrates were known by Tanaka for use in selective epitaxy of III-V semiconductors of which GaAs and GaN are well known examples (Final Rejection page 5, second paragraph). This is the only basis provided by the Final Rejection in support of the rejections of claims 20-23.

In rejecting claims for want of novelty or for obviousness, the examiner must cite the best references at the examiner's command. When a reference is complex or shows or describes inventions other than that claimed by the applicant, the particular part relied on by the examiner must be designated as nearly as possible (37 CFR §1.104(c)(2)).

A brief inspection of Tanaka's 34-column specification and nineteen sheets of drawings provides overwhelming support for a conclusion that this reference is extremely complex. The Final Rejection does not cite any particular part of Tanaka in support of the obviousness rejections of claims 20-23. Therefore, the evidentiary record fails to adequately support a *prima facie* case of obviousness.

Moreover, regardless of whether GaAs and GaN are well known examples of III-V epitaxial semiconductor films and whether sapphire or GaAs substrates were known to Tanaka, these statements alone fail to suggest the claimed combination. Tanaka fails to disclose or suggest: (1) introducing atomic, molecular, or chemical beams of Si, GaAs,  $_{1-x}^{Al_x}As$ , ZnSe, ZnS, CdTe,  $_{1-x}^{ZnS_x}$ , or YBCO onto the surface of a substrate of Si, GaAs, ZnSe,  $SrTiO_3$ , or sapphire and (2) introducing the beam at an incident angle of not more than 40 degrees with respect to the substrate surface, as recited by claim 20.

Tanaka fails to disclose or suggest: (1) introducing atomic, molecular, or chemical beams of Si, GaN, GaAs,  $_{1-x}^{Ga_x}As$ , ZnSe, ZnS, CdTe,  $_{1-x}^{ZnS_x}Se$ , or YBCO onto the surface of a substrate of Si, GaAs, ZnSe, or SrTiO<sub>3</sub>, and (2) introducing the beam at an incident angle of not more than 40 degrees with respect to the substrate surface, as recited by claim 21.

Tanaka fails to disclose or suggest: (1) introducing atomic, molecular, or chemical beams of Si, GaAs,  $_{1-x}^{Ga_x}As$ , ZnSe, ZnS, CdTe,  $_{1-x}^{ZnS_x}Se$ , or YBCO onto the surface of a substrate of Si, GaAs, ZnSe, SrTiO<sub>3</sub>, or sapphire, (2) introducing the beam at an incident angle of not more than 40 degrees with respect to the substrate surface, and (3) forming a single crystalline film of a first molecular structure on the surface of a single crystalline substrate of a different molecular structure, as recited by claim 22.

Tanaka fails to disclose or suggest: (1) introducing atomic, molecular, or chemical beams of Si, GaN, GaAs,  $_{1-x}^{Ga_x}As$ , ZnSe, ZnS, CdTe,  $_{1-x}^{ZnS_x}Se$ , or YBCO onto the surface of a substrate of Si, GaAs, ZnSe, or SrTiO<sub>3</sub>, (2) introducing the beam at an incident angle of not more than 40 degrees with respect to the substrate surface, and (3) forming a single crystalline film of a first molecular structure on the surface of a single crystalline

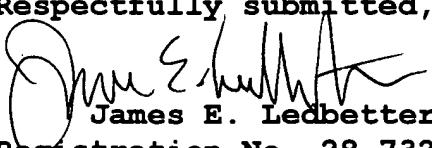
substrate of a different molecular structure, as recited by claim 23.

In accordance with the above discussion, Applicant submits that Tanaka, Tokunaga, and Nakamura, either alone or in combination, fail to disclose or suggest all of the features of instant claims 20-23. Furthermore, Applicant submits that the evidentiary record fails to support a *prima facie* case of obviousness regarding these claims. Therefore, allowance of claims 20-23 is warranted.

In view of the above, it is submitted that this application is in condition for allowance and a notice to that effect is respectfully solicited.

If any issues remain which may best be resolved through a telephone communication, the Examiner is requested to telephone the undersigned at the local Washington, D.C. telephone number listed below.

Date: March 24, 2004  
JEL/DWW/att

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